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THE CRANBERRY GIRDLER.[1]

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IMPORTANCE OF THE PEST.

The severity of the attacks of the cranberry girdler (*Crambus hortuellus* Hübner) upon cranberry vines, together with its general distribution throughout the cranberry-producing regions of the United States, marks this pest as one of prime importance to this industry.

The investigations into the seasonal history of the girdler and the observations on various methods employed to control it were made in New Jersey throughout a period covering nearly four years.[2]

Bog-management practices in New Jersey are diverse, and many opportunities have been offered to note the effects on cranberry-girdler infestations following one practice or another. Although it was stated by Smith (9, p. 21–24)[3] in 1903 that there is no such destruction of large tracts in New Jersey as in Massachusetts, it is apparent at this time that the girdler has become more of a pest each year. Smith's statement no longer holds true for New Jersey bogs, owing to the fact that many large areas of cranberry vines have been utterly destroyed by the insect in recent years.

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[1] *Crambus hortuellus;* order Lepidoptera, family Pyralidae, subfamily Crambinae.

[2] During the field seasons of 1914 and 1915 the writer was assisted by Mr. H. K. Plank, of the Bureau of Entomology, and opportunity is here taken to acknowledge Mr. Plank's services, particularly in the field of insect photography. The work has been under the general supervision of Dr. A. L. Quaintance, Entomologist in Charge of Deciduous Fruit Insect Investigations, Bureau of Entomology.

[3] Reference is made by number to "Literature cited," p. 19.

Owing to its habit of feeding concealed in trash under the vines, the worm is very difficult to find and has been overlooked by many growers who were aware of the injury but uncertain as to the cause.

HISTORY.

The cranberry girdler has figured in entomological writings as a pest of grasses and will be found referred to in that connection as the " garden crambid " or " garden veneer." In cranberry districts it is frequently spoken of as the " girdle worm," but the generally accepted name for the species is the " cranberry girdler."

From the time of its description by Hübner (1, p. 29, pl. 7, figs. 45, 46) in Europe until the work of Scudder (5) and of Felt (6, p. 75–76, 87–88, 99–100; fig. 7; pl. 3, fig. 19; pl. 9, fig. 19; pl. 14, fig. 19) little was known of its habits. The American form was first described by Zeller (3, p. 155–156) under the name of *Crambus topiarius*, and later by Grote (4, p. 74), who stated that Zeller considered *topiarius* to represent the European *hortuellus* in the American fauna. Of late years the girdler has been the subject of considerable study in Massachusetts by Franklin (10, p. 7–8).

DISTRIBUTION.

This pest is not confined to the cranberry-growing sections, but is widespread throughout the United States, Europe, and Canada. Originally described as a European species, it is listed by Wood (2, p. 216, pl. 47, fig. 1497, *n*) from various parts of England and by Felt (6, p. 99) from St. John, New Brunswick, Canada. Felt gives the distribution as Maine, Massachusetts, North Carolina, Illinois, Nevada, and California, from which it may be noted that the species occurs practically from one end of this country to the other, and it is probable that it will be recorded eventually from every State in the Union. In the cranberry districts of Massachussetts and New Jersey it is very abundant, and in New Jersey especially it may be said that the majority of bogs show more or less injury by this species. It is common in Wisconsin, but has not become a serious cranberry pest, probably because the bog floors, as a rule, are kept wetter than those in the eastern cranberry States.

FOOD PLANTS.

The early records mention this insect as having been found commonly on grasses, but just what grasses is not specified. Fernald (7,

p. 40, fig. 1) gives sheep sorrel as a host. In later years cranberry is mentioned frequently. On cranberry the larvæ confine their feeding to the woody parts, such as the runners and the larger roots, and occasionally some of the finer roots are taken.

The investigation in New Jersey shows that a sedge, commonly called "three square" (*Scirpus americanus*), is fed upon liberally when present in cranberry bogs. This is one of the abundant bog weeds, and the larvæ attack it at the crown, sometimes forming their cocoons in this situation.

FEEDING HABITS AND DESTRUCTIVENESS.

All the injury is done during the larva stage, beginning in early June and continuing throughout the summer and fall until about mid-October. The worms are slow of growth, and the dying of the vines can not be detected readily until late August or September. During the early part of the season the worms are small and feeding is not extensive, but in late summer, when the worms are nearly full grown, they are ravenous feeders, and the lessened vitality of the vines is evidenced by the appearance of the foliage, which becomes fiery red or brown in September and October. Large quantities of the leaves drop off, and the few which remain on completely girdled vines become dry and drop during the winter, leaving areas of dead vines denuded of foliage presented to the view the following summer. Such dead areas may vary in size from a square foot to spots containing many square rods. At the close of a second year of infestation many of these dead areas will become merged, owing to the dying out of the vines in the intervening areas, by further girdler feeding. Under such conditions it is common to find areas of dead vines, leafless and very conspicuous by their black color, comprising as much as one-half acre (Pl. I). Usually the vines around the margins of the dead areas die back a little farther each succeeding year, although if the work of the girdler ceases, runners may spread out over the dead vines and tend to re-cover the area. This, however, is a very slow process, involving several years, and in the meantime the spot very frequently becomes a verdant patch of grass or sedge. In certain bogs small areas 2 or 3 feet in diameter (Pl. II, *A*) may be killed, particularly where the trash is very thick beneath the vines, as is likely to be the case in some of the corners, and the damage will not grow to alarming proportions. Such areas vary little in appearance from year to year until at some time the girdlers are exterminated, perhaps by a prolonged flooding of the bog. Then the runners push out and eventually fill in the bare spaces.

Where girdler feeding has not been severe enough completely to kill the vines, and even in those places where only slight gnawing of the runners has occurred, in a number of bogs it has been noted that such areas develop more rotten fruit than do adjacent vines in healthy condition. The weakening of the vines apparently tends to make the fruit more susceptible to fungous attack.

In severe cases of girdler feeding the vines may become so loosened, or so badly eaten and severed, that they may be rolled back with slight exertion, exposing the bare trash beneath.

Girdled vines are often found on which injured portions, where the bark has been abraded, are covered with white cottony material; these are the waxy coverings of mealy bugs (*Pseudococcus adonidum* L.), and as they are rarely found on healthy vines they should be classed as secondary pests.

The specific injury caused by the feeding worms is due to their eating through the bark of the runners into the wood, which often occurs to such an extent that the runner is completely severed. (Pl. III, *A*, *B*.) Gnawing the bark completely around a runner will also kill that part of the plant beyond, provided no other roots nourish this part. Runners are often seen which have been tunnelled for short distances by this insect, and some are eaten down to mere splinters. The fine roots as well are eaten, but to a less extent than is the woody part. Feeding marks are sometimes found on the crowns of the plants where they arise from the hills as originally set. Practically all of the feeding, however, is done by the larvæ in a concealed position—in the trash which is found beneath the vines, which consists largely of fallen leaves, pieces of vines, and other débris, and forms a mat over the runners, affording the girdlers excellent protection from parasitic insects.

The feeding marks of the cranberry girdler should not be confused with those of the cranberry rootworm (*Rhabdopterus picipes* Oliv.), which feeds on the small roots and root hairs and on the runners only to the extent of eating the bark, usually on the side which touches the ground. In general, the rootworm feeds below the surface of the ground, whereas the girdler feeds above the surface but hidden in a layer of trash. The excrement of the girdler in badly injured areas is very abundant, appearing in masses, which indicates that the larva feeds for a considerable length of time without materially changing its location. Often the excrement, intermixed with bits of trash, will be found with silken threads woven loosely through it, and these rude galleries probably constitute a protective covering for the worm during the feeding period. Scudder (5) figured a cylindrical, upright case for this larva occurring on grasses, and Fernald (8, p. 150) speaks of a vertical tube, constructed of bits of vegetable material held together by silk, but neither of these larval cases has been found on New Jersey cranberry bogs, and for this reason the larvæ are described as being naked.

DESCRIPTION OF THE CRANBERRY GIRDLER.

THE EGG.

The egg (Pl. IV, *D*) is white when first laid, becoming more and more pinkish as hatching time approaches. It is oval in outline, broadly rounded at the ends, with the end through which hatching occurs slightly more tapering than the base. The apex is divided into a number of cells of various patterns. The sides are ribbed vertically, usually regularly, but not always. These are crossed longitudinally by much finer ribs. The average size of four eggs is as follows: Length, 0.441 mm.; greatest breadth, 0.318 mm. Fifty-eight eggs laid end to end would measure about 1 inch.

THE LARVA.

The last-stage larva (Pl. IV, *A*, *B*) has a dark-brown head with ocelli, mandibles, and labrum black; the clypeus is dark brown, the thoracic shield and tip of abdomen light amber, and the rest of the body sooty white, bearing numerous long and short hairs which are black at the base and finely pointed. Its length is 12 to 15 mm., or about one-half inch.

THE PUPA.

The general color of the pupa (Pl. IV, *C*) is pale yellow with eyes becoming black before the emergence of the moth; the tip of the abdomen is dark brown, the outlines of the wings and the antennæ are brown, and the segments of the abdomen are edged with brown. The length is 8.5 to 11 mm., or about three-eighths of an inch.

THE ADULT.

Scudder (5) gives the following description of the adult (Pl. V, *A*, *B*.):

> Fore-wings above of a pale straw color, growing pale buff apically heavily marked with blackish fuscous of varying shades and with silver; the latter is mostly confined to two subapical cross-bands, the upper half of the inner and the whole of the outer oblique, the inner bent just above the middle and crossing the entire wing (excepting that it fails to reach the costal margin above), the lower half at nearly right angles to the upper half and subparallel to the outer margin; the inner band is bordered interiorly with brown which extends to the costal margin; a broad stripe of silvery gray tapering apically follows the subcostal vein to the end of the cell and four fuscous longitudinal stripes reach nearly or quite to the inner silvery band, the uppermost more or less mingled with buff following the costal edge for nearly a third its length and then running a little obliquely across the upper extremity of the cell, the next tinged with silver so as to become pearl gray extending along the middle of the cell; the other two follow the median and submedian nervures; three other short longitudinal fuscous lines, much overlaid and concealed by silver,

follow the nervules beyond the cell, while a supplementary brownish and oblique line intervenes between the oblique portion of the costal stripe and the inner margining of the inner silvery band; the extreme outer margin of the wing has a black line on the upper half, and on the lower half at the nervule tips three or four black points; the fringe is silvery. Hind-wings uniform silvery gray, narrowly edged on the upper half of the outer border with pale brown, the fringe silvery white. Expanse of fore wings, ♂ 15^{mm}; ♀ 17^{mm}. Described from four bred males.

The average length of 14 specimens, measuring from front of eye to tip of wing when folded, is 9.4 mm., or about three-eighths of an inch. The females are rounder of abdomen and average larger than the males.

THE COCOON.

The cocoon is composed of scraps of débris found on the floor of the bog, usually consisting of bits of dead leaves, bark, twigs, fine roots, grasses, sand, and dried excrement of the larva, with now and then a whole leaf attached loosely to the outside. This material is held together by fine strands of white silk, and the interior has a lining of white silk, parchmentlike in texture. In sandy locations the external part of the cocoon is sometimes made entirely of sand. However, for New Jersey bogs the typical cocoon is made of trash and appears dark brown in color.

The shape of the cocoon is variable (Pl. VI, *B.*). In some instances it might be described as resembling in miniature a short-handled Indian club, while others appear of a curved cucumber shape. One end is always broadly rounded, being of greatest diameter about one-third the distance to the smaller end, and tapering to a cylindrical, slightly curved neck. Some loose strands of silk are placed in the neck for protection, but the end is not securely sealed as are the walls. When pupation occurs the pupa lies with head toward the neck, and the moth is able to push its way through, leaving the pupal shell within the cocoon. One can not tell from external appearances whether the moth has emerged, because the exit hole is well concealed by the arrangement of pieces of trash which tend to fall back into position after the passage of the moth. The measurements of 13 cocoons are as follows: Length 11 to 18 mm., average 13.84.; greatest breadth 5.5 to 10 mm., average 6.88 mm.

Vertical cylindrical cases often encountered on cranberry bogs, which might be confused in the mind of the grower with those of the girdler, are those formed by larvæ of caddiceflies—harmless insects which breed in wet places. There are many styles of these caddicefly cases (Pl. VI, *A*), and they are often found projecting straight up through the trash in areas infested by the cranberry girdler.

SEASONAL HISTORY.

The seasonal-history data were secured on numerous bogs throughout the State of New Jersey and in rearing cages kept in a screened open-air insectary. Four-ounce ointment cans were satisfactory for securing the feeding, cocooning, and pupation data, while for oviposition data and caging the moths a cloth-covered lamp chimney was found to fit tightly over a 1-ounce ointment can.

ADULT STAGE.

The time of emergence in the spring and summer depends largely upon whether the bog is a dry one or a flowed one and on the date of drawing the winter flowage.

Dry-bog conditions.—Cocoons kept at the laboratory during the winter of 1914–15, under approximately dry-bog temperatures, yielded moths from May 11 to June 18. In the cranberry bog where winter flowage was removed on April 10, moths began flying June 7.

Winter flowage drawn May 10.—This represents probably the average date at which New Jersey growers remove the winter flowage. From a large mosquito-bar cage placed over an infested area of cranberry vines bared of winter flowage on the 10th of May, adult emergence was noted from June 10 to July 8. The complete record appears in Table I.

TABLE I.—*Emergence of cranberry-girdler moths on cranberry bog, Whitesbog, N. J., 1915.*

Date of removal from cage.	Number of moths.	Date of removal from cage.	Number of moths.
June 10	16	June 18	38
June 11	48	June 25	10
June 12	42	July 2	1
June 15	117	July 8	1
June 16	24		

Keeping the winter flowage on a bog until some time after May 10, in the region of New Jersey, produces a later emergence of moths. There is a date, however, which no one as yet has determined definitely, when, owing to the lateness of holding the flowage, the immature stage of the moth is killed. One observation was made in 1916 on a bog at Howardville, N. J., showing that, although the winter flowage had been held until July 12, a number of the girdlers in the immature stages were able to survive this treatment, and moths were found flying August 3.

On grassy bogs and on bogs bearing a heavy mat of vines the emergence of the moths may be prolonged over a long period. At

Whitesbog, N. J., records of late-flying moths have been kept for three years, and it is not unusual to find them flying until mid-August. The heavily shaded places, from which the flowage is slow in draining, probably retard the development of the immature forms in the cocoons and thus give rise to later issuing moths. These are the conditions which have led to the erroneous conclusion that more than one brood occurs in the course of a season.

The moths, which are strong fliers, are seldom noted in their concealment among the vines, but when disturbed they fly several rods or more, finally seeking shelter in the vines again and often running down to the trash for security. When resting, the moths fold the wings tightly around the body and are inconspicuous; at night, with the aid of a lantern, they may be seen in this position clinging to vines or the stems of tall grasses.

Proportion of sexes.—In the early summer the males and females appear to be about equal in number; for example, on June 11, 24 moths were collected, of which 12 were males and 12 were females. In late summer, however, the males are far in excess of the females, as shown by the following collections: Thirteen moths taken July 27 consisted of 11 males and 2 females, while of 23 moths collected August 10 only 5 were females.

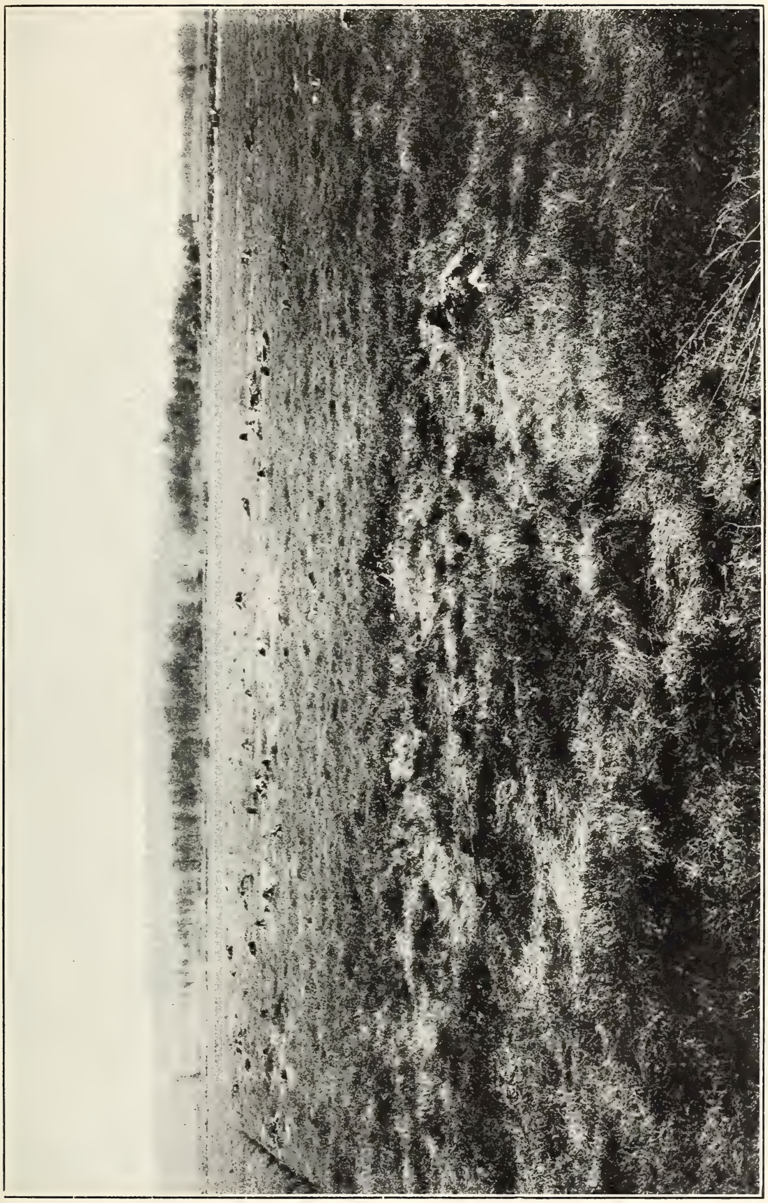
EGG STAGE.

In rearing cages the moths laid eggs from various positions, not necessarily resting on the bottom of the cage, but dropping the eggs from whatever position they happened to have assumed. No eggs were found attached to the cranberry vines or sides of the cage, but all were recovered on the cage floor. It is assumed, then, that on the bogs the eggs are laid either when the moths have crawled down to the trash or when they are clinging to vines or grasses. The eggs are so minute that there is little possibility of finding any under natural bog conditions.

The moth has been known to be a prolific egg layer. Felt (6) records one female that laid 700 eggs, 300 of them being deposited on the first day. In the course of observations at Whitesbog, N. J., a female was noted which laid 50 eggs in less than two hours.

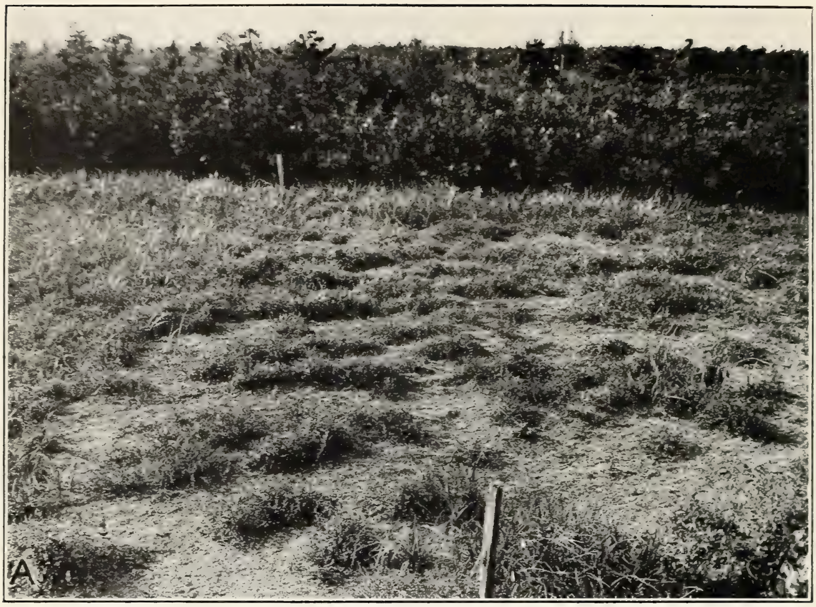
The data in Table II give the number of eggs per female secured at Whitesbog, N. J., under insectary conditions.

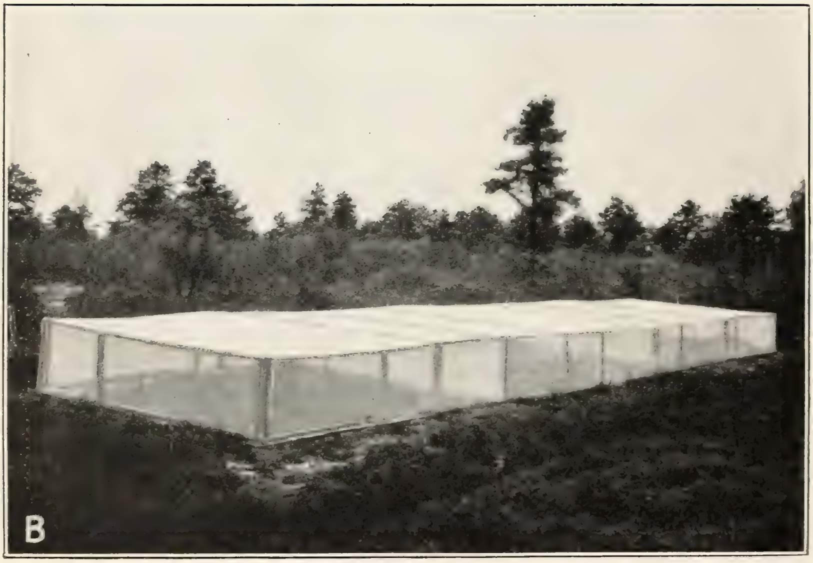
A male and female (reared) were placed in each cage and fed sugar sirup.



WORK OF THE CRANBERRY GIRDLER (CRAMBUS HORTUELLUS).

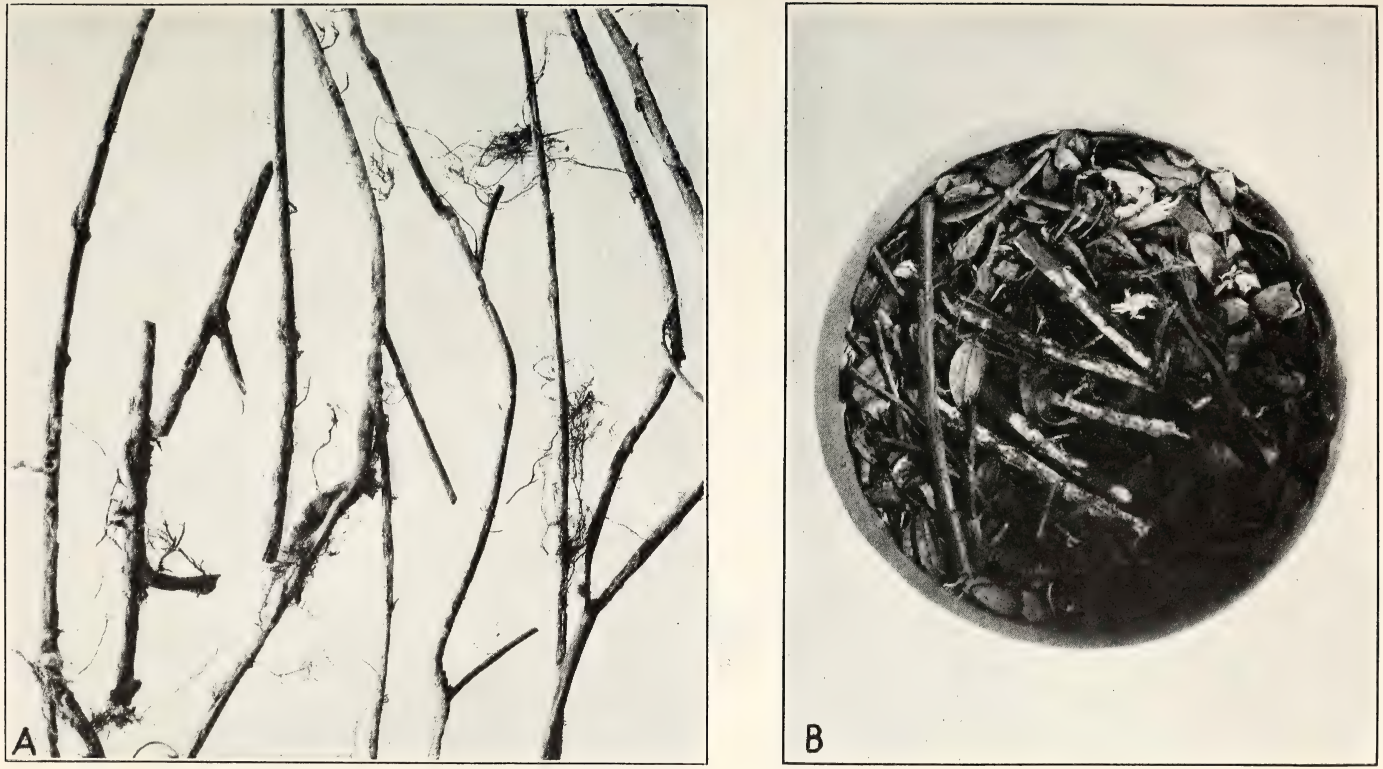
Severely injured cranberry bog, showing large dead area in foreground and smaller dead areas beyond. (Original.)





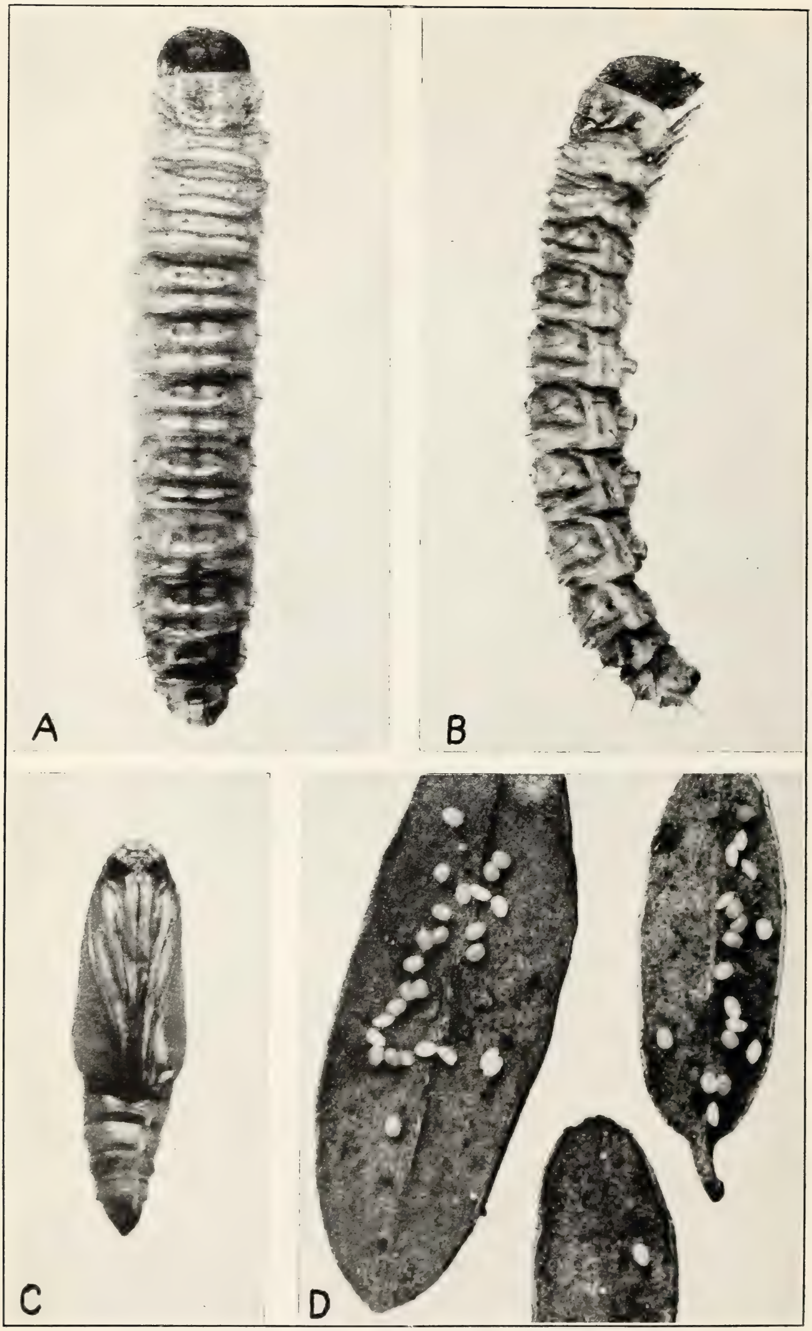
THE CRANBERRY GIRDLER.

A.—Mild case of injury to cranberry vines. B.—Cage used in sanding experiment at Whitesbog, N. J. (Original.)



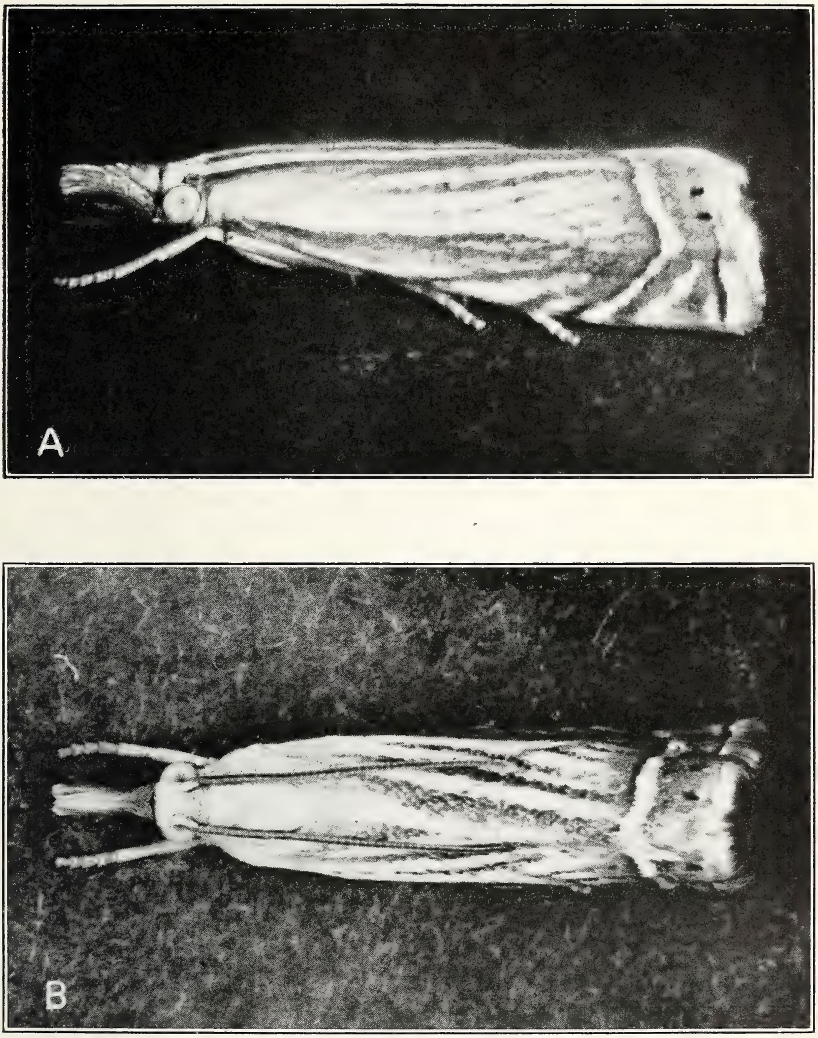
DAMAGE BY THE CRANBERRY GIRDLER.

A.—Cranberry runners gnawed by the larvæ. B.—Larval feeding marks on cranberry vines in rearing cage. (Original.)



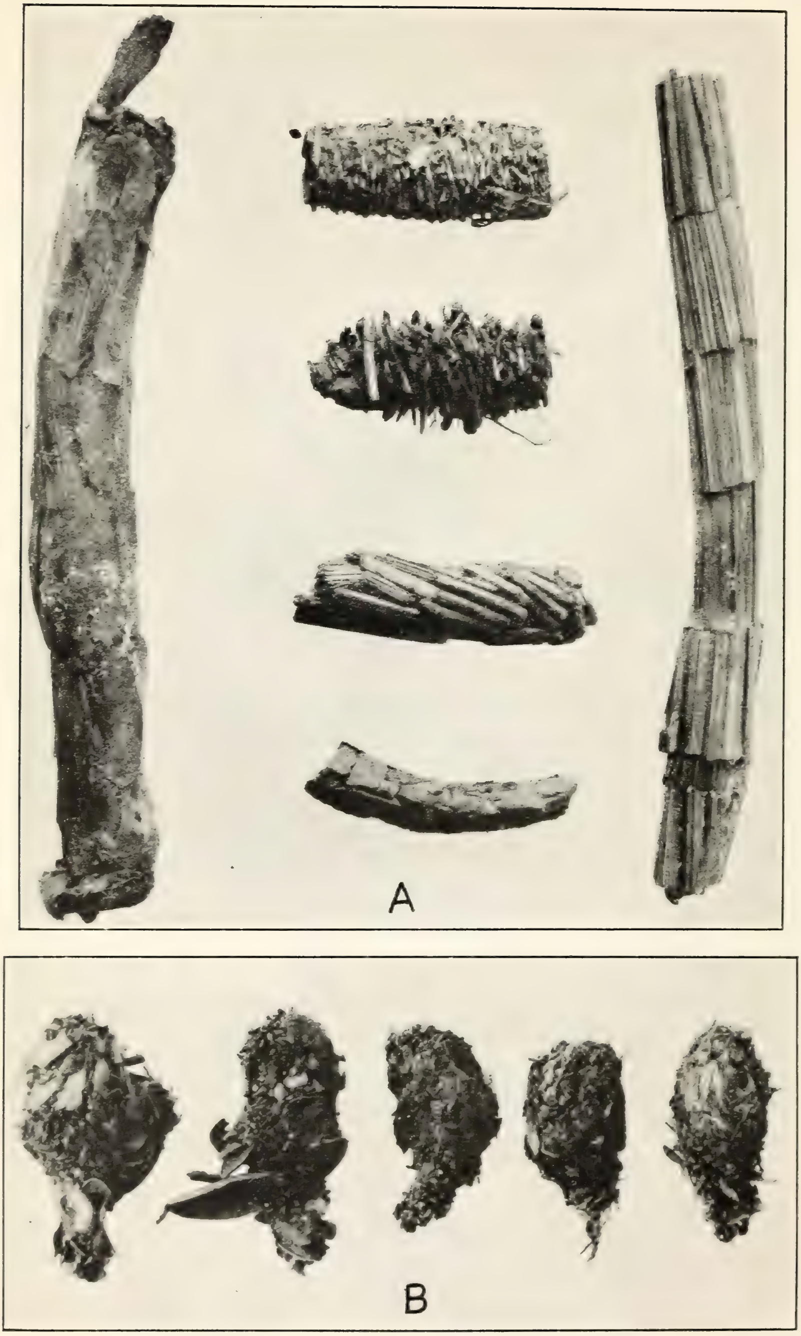
STAGES OF THE CRANBERRY GIRDLER.

A.—Dorsal view of last-stage larva, enlarged 9 times. B.—Lateral view of last-stage larva, enlarged 9 times. C.—Pupa, enlarged 6 times. D.—Eggs on fallen cranberry leaves. (Original.)



THE CRANBERRY GIRDLER.

A.—Adult moth, viewed from side. B.—Adult moth viewed from above. Photographed from life, enlarged 9 times. (Original.)



COCOONS OF CRANBERRY GIRDLER AND CADDICEWORMS.

A.—Caddiceworm cases, sometime mistaken for those of the girdler, twice enlarged. B.—Types of cocoons of cranberry girdler, twice enlarged. (Original.)

TABLE II.—*Number of eggs per female of the cranberry girdler, Whitesbog, N. J., 1915.*

Pair No. 1.		Pair No. 2.		Pair No. 3.		Pair No. 4.	
Date of deposition.	Number of eggs.	Date of deposition.	Number of eggs.	Date of deposition.	Number of eggs.	Date of deposition.	Number of eggs.
June 9	7	June 1	1	May 22	79	July 24	55
June 10	98	June 2	1	May 23	103	July 25	8
June 11	30	June 3	1	May 24	0	July 26	78
June 12	12	June 4	6	May 25 and 26	32	July 27	21
June 13	14	June 5	17	May 27	9	July 28	49
		June 6	59	May 28	12	July 29	3
		June 7	75			July 30	17
						July 31	12
	161		160		235		243

The greatest number of eggs laid in a single day by one female was 103, and the greatest number laid during the life of a given female was 243. The length of the egg stage varies with the season, those eggs deposited in May requiring a longer incubation period than do those laid in July, as shown in Table III.

TABLE III.—*Length of the egg stage of the cranberry girdler, Pemberton and Whitesbog, N. J., 1915.*

Date of deposition.	Date of hatching.	Length of stage.	Date of deposition.	Date of hatching.	Length of stage.
		Days.			*Days.*
May 21	June 8	18	July 25	Aug. 1	7
May 22	do	17	July 26	do	6
May 23	do	16	Do	Aug. 2	7
Do	June 10	18	July 27	Aug. 3	7
May 26	June 11	16	July 28	Aug. 5	8
June 9	June 17	18	July 30	Aug. 6	7
June 10	do	7	July 31	do	6
June 11	June 19	8	Aug. 7	Aug. 13	6
June 12	do	7	Aug. 9	Aug. 15	6
July 24	Aug. 1	8			

Average length of the egg stage, 9.63 days.

LARVA STAGE.

The larva leaves the egg through a hole which it cuts in the apex, or slightly to one side of the apex, and emerges as soon as the aperture is large enough to permit the passage of the head, crawling rapidly out and appearing very active at this period. In small cans the larvæ were fed fine cranberry roots, the bark and wood feeding habit being acquired apparently during later life. As remarked by Ainslie (12), some species of Crambinae defy all attempts to rear the larvæ, and *C. hortuellus* falls into this class in the experience of the writer.

Investigations conducted in this region demonstrated beyond doubt that there is only one generation annually. Field records kept on a number of badly infested bogs throughout the entire season showed only a single flight of moths from about June 10 to mid-July, after which there was no further evidence of moths until the following year. This was also demonstrated in a mosquito-bar cage covering 2.4 square rods, from which moths issued from June 10 to July 8, and although oviposition occurred in the cage, none of the larvæ pupated during that season.

Larvæ are rarely found in wet situations or in places where a lack of drainage is materially affecting the productiveness and health of the vines.

The drier locations, such as knolls, the high margins of the bogs, and well-drained areas having a considerable quantity of fallen leaves and trash under the vines are the places injuriously infested. The character of the soil is not so important a limiting factor as the drainage. Severe injury occurs on mud and peat bottoms as well as on savannas, provided a good layer of trash is present and the land is well drained.

Larvæ are never found feeding in exposed positions, but always buried beneath more or less trash. When exposed to the light, as when trash is turned over, they usually are found in a curved position and motionless. After a period of about 10 seconds the larvæ will start crawling rapidly for cover, and it is at this time that they are most easily detected. The trashy nature of the infested situations also renders their location difficult. Many growers have failed utterly to locate the larvæ, although the vines may have shown injury of an extreme type.

The amount of damage done by the cranberry girdler seems out of all proportion to the number of larvæ to be found in a given location. In one instance, however, the writer found 30 cocoons containing larvæ and 1 naked larva in an area of about 4 square feet.

What appears to be the most important point in the seasonal history of this pest from the standpoint of its control is the period when cocoon making begins. The few publications available on the seasonal history of the cranberry girdler present various statements regarding the time of cocooning. Some writers have placed the period as late as November, and others have indicated this period as beginning at varying dates in September and October. Realizing the importance of knowing more definitely when cocooning commenced, the writer has made collections of larvæ and cocoons in the fall, and from these data it may be stated for New Jersey conditions that some larvæ form cocoons in late September and the majority in early October. Records obtained from bogs in different localities are shown in Table IV.

TABLE IV.—*Cocooning records of the cranberry girdler in New Jersey, 1915.*

Date.	Number of larvæ in cocoons.	Number of naked larvæ.	Date.	Number of larvæ in cocoons.	Number of naked larvæ.
Sept. 8	0	21	Oct. 5	9	1
Sept. 14	0	15	Oct. 11	6	1
Sept. 19	0	7	Oct. 15	37	1
Oct. 1	3	17	Oct. 19	1	0
Oct. 4	0	2	Nov. 17	26	0

The foregoing figures, obtained under actual bog conditions, show that cocoons were first found October 1, although search was not made for them between September 19 and that date. Naked larvæ were abundant on October 1, but this condition soon changed, and by the 5th of October larvæ in cocoons outnumbered the naked ones.

After making the cocoon, the larva lies dormant within until spring of the following year, at which time pupation occurs. Larvæ in cocoons are able successfully to withstand the usual winter flowage, which is applied, as a rule, in December and held until the following April or May. Some few are able to withstand a flowage lasting until July, although an infestation is always greatly reduced by such late holding.

The cocoon is not impervious to water and, in fact, becomes filled with water about three days after submergence. After 24 hours' submergence in a solution tinged with red, the inner wall of the cocoon was found entirely reddened, with no free water around the larvæ. Similar results were obtained with another cocoon after 48 hours' submergence, while at the end of four days three cocoons were entirely filled with the solution.

PUPA STAGE.

Pupation occurs after the removal of the winter flowage and is dependent upon the time of this removal. On dry bogs it may occur in late April or May, and on winter-flowed bogs it may be retarded by late holding of the flowage until July. No evidence has been noted of pupation taking place while the winter flowage was on; in fact, the examination of cocoons within a day or two after the drawing of the winter flowage showed all such to contain larvæ.

After pupation has occurred the bog may be reflowed for several days without effecting the death of the pupa. On one occasion a pupa in its cocoon was found alive on the bog after submergence for between five and six days.

Pupal records have been difficult to obtain, because the opening of the cocoon for purposes of observation is disturbing to the larva and is likely to result either in its death or in delaying its transformation to the pupa. The records at hand show that the stage lasts, on the average, 21 days. (See Table V.) Under natural bog conditions, following the drawing of the winter flowage about May 10, it is very likely that the pupal period is several days shorter in duration than as stated. The pupa is always found with the head pointing toward the neck of the cocoon, eventually permitting the easy emergence of the moth.

TABLE V.—*Length of pupa stage of the cranberry girdler, Pemberton, N. J., 1914.*

Experiment No.	Date of pupation.	Date adult emerged.	Length of stage.	Experiment No.	Date of pupation.	Date adult emerged.	Length of stage.
			Days.				*Days.*
1	Apr. 28[1]	(2)	....	9	Apr. 30	(2)	....
2	Apr. 29[1]	May 11	12	10	May 2	(2)	....
3	...do....	May 15	16	11	...do....	May 18	16
4	...do....	May 18	19	12	...do....	...do....	16
5	...do....	May 20	21	13	May 7	June 5	29
6	...do....	May 27	28	14	May 23	June 13	21
7	...do....	May 29	30	15	May 29	June 17	19
8	Apr. 30	...do....	29	16	...do....	...do....	19

Average days, 21.15. [1] Approximate. [2] Died.

NATURAL ENEMIES.

Among the parasites there appear to be very few which attack the cranberry girdler. No parasites were obtained in the rearing cages, but occasionally when opening cocoons the remnants of a parasite in one stage or another were found. From such findings two species of Ichneumonidæ were secured. The habit of concealed feeding of the girdler larvæ must be a great protection against parasitic enemies, and the winter flowing of the bogs probably also tends to lessen the activities of parasites.

In areas of severe girdler infestation spiders have been found to be very abundant as well as have various species of ground beetles. Among the ground beetles *Harpalus caliginosus* Fab. and *Anisodactylus harrisii* Lec. have been collected.

Very often an area of vines infested with girdler larvæ will be invaded by field mice, and the burrows just beneath the surface will run throughout the entire section. While mice occasionally cut off cranberry vines which are in the line of a runway, they should be classed as minor pests of the cranberry industry. The work of mice may be recognized by the diagonal cut of the severed vine and the furrows made across the end by their teeth. It is thought, however, that the mice search for girdler larvæ and are instrumental in reducing large infestations. They nest in roundish houses built of grasses above the level of winter flowage.

Among the birds which prey on insects the swallows are perhaps the most useful in capturing girdler moths. At Howardville, N. J., a swallow followed the writer the length of one of the bogs, and as

PLATE VII.

A SEVERE REMEDIAL MEASURE AGAINST THE CRANBERRY GIRDLER.

Burning a cranberry bog, a practice occasionally resorted to in very severe outbreaks. (Original.)

the moths, frightened from the vines, rose into the air the swallow darted for them and captured many.

At present, natural enemies do not appear to be potent factors in the control of the girdler on cranberry bogs.

REMEDIAL MEASURES.

Under the heading of remedies fall such methods of treatment as spraying, the use of repellents, burning, trap lights, flooding, and sanding. Of these measures, flooding and sanding have given the best satisfaction, as indicated by the work conducted in New Jersey.

SPRAYING.

Owing to the habit of the larvæ of feeding on roots and runners under cover of the trash beneath the vines, there seems to be no hope of developing a method of combating them in which reliance can be placed on spraying. In addition to the trash which hides the larvæ, the dense mat of vines covering the bog prevents a large portion of the spray material from reaching even the trash.

REPELLENTS.

It has been suggested occasionally by growers that commercial fertilizers might act as repellents of the girdlers and at the same time stimulate the vine growth. The opportunity to study this method of treatment was afforded at Whitesbog, N. J., where fertilizer experiments on cranberry bogs have been carried on by the New Jersey experiment station for a period of four years. No fertilizer was applied to the plats the fourth year, owing to the excessive vine growth produced during the previous three years. Muriate of potash has been held by some to afford protection from certain insects owing to its repellent action, and four of the plats to which this material was applied, along with other ingredients, were kept under observation by the writer. The data in Table VI[1] show the fertilizers and the amounts applied on four plats, consisting of one-twentieth of an acre each.

TABLE VI.—*Experiment with fertilizers as repellents against the cranberry girdler, Whitesbog, N. J., 1915.*

Plat No.	Fertilizer tested.	Plat No.	Fertilizer tested.
11..........	10 pounds muriate of potash, 25 pounds acid phosphate, 10 pounds ammonium sulphate.	29..........	10 pounds muriate of potash, 15 pounds phosphate rock, 10 pounds ammonium sulphate.
13..........	10 pounds muriate of potash, 25 pounds acid phosphate, 20 pounds dried blood.	31..........	10 pounds muriate of potash, 15 pounds steamed bone, 10 pounds ammonium sulphate.

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[1] Extracted from Proceedings of the 46th Annual Meeting of the American Cranberry Growers' Association.

The fertilizers listed in Table VI have been of no avail in repelling the girdlers; in fact, these plats in 1916 showed serious injury, as evidenced by the considerable areas of girdled vines found on them. In general, it may be said that the use of fertilizers tends to make conditions more favorable for girdler infestation by increasing the amount of vine and foliage production and thus in direct proportion increasing the trash on the ground beneath the vines. This, however, should not deter anyone from using fertilizers on cranberry bogs where the vines need stimulation, but should be taken as a caution that girdler infestation is likely to follow a heavy production of vines, particularly on well-drained land.

In a test to determine the repellent value of certain materials a lumpy and granular residue, said to be a by-product of a gasworks, was applied to an infested piece of land by broadcasting at the rate of 650 pounds per acre. The larvæ were not repelled and were as abundant at the time of cocooning on the treated plat as on the adjacent untreated plats.

BURNING.

Burning infested areas has been recommended in the past and occasionally has been resorted to by growers. When a bog is burned over (Pl. VII), a large quantity of the trash remains unconsumed on the bog floor, but it is probable that the heat generated is great enough to kill the larvæ, naked or in cocoons, that may have been buried in this débris. Other methods of controlling the girdler have been devised which do not entail destruction of the vines by burning, and the practice therefore is not recommended.

TRAP LIGHTS.

Capturing the moths by trapping with lights was tried for two seasons with very unsatisfactory results. On one occasion four moths were captured at a stationary light in the course of a night. The tests with lights were made in the height of the flying season, and the results showed conclusively that the moths are not attracted to lights in sufficient numbers to warrant employing this method of capture.

LATE HOLDING OF THE WINTER FLOWAGE.

By late holding of the winter flowage is meant maintaining the winter head of water over the vines from the time it is applied in December or thereabouts until some time between July 1 and August 1. Holding the flowage until July 1 does not always satisfactorily destroy girdler infestations, but if the head is maintained until July 15 much better results are obtained. Occasionally a grower is met who has kept the water on the bog until August 1, and, while this treatment is very satisfactory from the standpoint of destroying the girdlers, it may result in a very poor bud formation and a light crop of berries the following year. Some of those who have tried holding the flowage until mid-July have reported that the crop the year following yielded an increase of 100 per cent over a normal one, showing that this treatment may be used without monetary loss, provided frosts, which may destroy part of the prospective double crop, are not encountered in the cropping year.

Holding the flowage until July 14 or later results in the loss of the current year's crop, but this procedure is good practice where the girdler infestation is severe and perhaps complicated by an infestation of the blackhead fireworm (*Rhopobota vacciniana* Pack.). Considerable expense is saved the grower by allowing the bog to go one year without a crop, and the treatment always results in producing a cleaner bog, especially if the one so handled has been invested by grass and weeds.

June 18 is the latest date, in the knowledge of the writer, to which the winter flood can be held and a good crop secured the same season. This was accomplished on a deep-flowed bog of Early Black vines near Pemberton, N. J.

In the event of holding the winter flowage until July 15, or a little later, successful control of the girdler will be secured, but not extermination. A few of the insects will escape even this treatment, and at the end of three or four years the infestation again may be severe. The mistake made by many growers is in permitting the injury to assume large proportions before attempting control. The first signs of girdler injury should be noted and the remedy applied before the pest gains headway and large areas of vines are destroyed. The presence of large numbers of the moths on a bog in June and July should serve as a warning that the vines are in a fair way of being severely damaged.

FALL FLOODING.

Fall flooding affords the most satisfactory control of the girdler, and will result in practical extermination of the pest until reinfestation comes from the upland or other bogs, if it is applied at the proper time. As shown in the study of the seasonal history, the larvæ make cocoons in the fall, and if the fall flowage is applied after the cocoon is formed, the larva within will not be injured, even though this flowage lasts two weeks or more. However, if the flowage is applied before cocoon making begins, the naked larvæ will be killed certainly in a week, and it is probable that five days is ample time for submergence, although some growers prefer to hold the flowage two weeks to insure a thorough treatment.

For New Jersey, cocoon making begins in a large way the first week in October, and it is therefore essential to reflow the bog during the latter part of September. If the bog is vined with a variety of early berries it will not be difficult to have them picked early so that flooding can be done at the proper time. With late berries, such as Howes, this treatment is not in vogue and some other remedy must be attempted. It is of course essential to have sufficient water in storage to accomplish the fall flooding, and a lack of storage water at this season of the year is the stumbling block which limits the practice of fall flooding to a very few of the New Jersey bogs.

If the fall flowage is applied later than the first week in October most of the worms will not be killed, as is shown in the following notes made on a bog at Mays Landing, N. J.: On October 15 the bog was examined and was found to have been severely damaged. A search for larvæ and cocoons was made, and 30 larvæ in cocoons and one naked larva were secured. The flowage was put on October 22 and held until November 8, a period of 17 days. On November 17 another examination was made, and 26 live larvæ and 1 dead larva in cocoons were collected. This treatment was therefore entirely unsatisfactory.

At Pemberton, N. J., a newly infested bog was flooded from September 19 to October 3, a period of 14 days, with the result that the following season no further dying of the vines occurred and no flight of moths was observed. This indicated very successful control.

Fall flooding immediately after picking the crop, whether this be early or late, is a treatment to be commended, even though girdlers are not present, since it helps in the control of the yellow-headed fireworm (*Peronea minuta* Rob.), the red-striped fireworm (*Gelechia trialbamaculella* Cham.), the toad bug (*Phylloscelis atra* Germ.), the blossom worm (*Epiglaea apiata* Grote), and other insects of minor importance.

SPRING FLOODING.

Wherever opportunity offered, examinations were made of bogs after the reflowage had been removed in the spring, to determine if flooding during the pupa stage for various lengths of time had killed the pupæ. In the season of 1915 a bog from which the winter flowage had been drawn on May 10 was reflowed June 9, and a certain area, known to be infested, was watched to ascertain the number of hours it was covered by the flowage. This period proved to be 24 hours, and soon afterward two cocoons, each of which contained a live pupa, were found upon the bog. Moths issued from these pupæ on June 15 and June 19. From another area on the same bog, which had been submerged about 30 hours, 11 cocoons were collected, and these yielded 10 pupæ. Moths issued from these pupæ as follows: June 14, three; June 15, two; June 16, one; June 17, three.

During the season of 1916 a bog was observed which had the following history: The winter flowage was drawn off on April 9. The first reflow lasted 5½ days on the girdler-infested area, or from May 12 to May 18. The second reflow was held 36 hours, dating from May 31, and the third reflow was removed at the end of 18 hours, on June 9. On June 12, three days later, girdler moths were found flying over the infested area, and since no other infestation existed near by, this was ample evidence that the three reflowings had not destroyed the immature stages.

On one occasion a live pupa was collected in its cocoon where the reflow had lasted 5½ days. The winter flowage had been drawn May 10, and the reflowing occurred from June 9 to June 15. Two weeks later girdler moths were very abundant on this area. These records indicate that spring reflows occurring during or near the pupa period and when held for periods lasting as long as 5½ days do not give control of the girdler.

SANDING.

There has been considerable hostility to the practice of sanding cranberry bogs by some of the New Jersey growers, due largely, it seems, to the fear of increasing the fungous troubles of this fruit. On the other hand, there are a few growers who, while not consistent "sanders," are greatly in favor of the practice although little, if any, experimental work has been performed in New Jersey to determine whether or not the losses due to fungous diseases have increased on sanded areas. It has long been customary in Massachusetts to sand the bogs, and such treatment has a well-recognized value in the control of certain cranberry insects, notably the cranberry tipworm (*Dasyneura vaccinii* Smith) and the cranberry girdler.

Sand should be spread on the bog in the fall, winter, or early spring, preferably in late fall so as to have it become well settled around the vines by the winter flowage. Occasionally, during cold weather, sand may be spread on the ice, resulting, when thawing ensues, in an even covering of the ground. For girdler infestations a layer of sand not less than 1 inch in thickness is required, and it will be found far better on most New Jersey bogs that have not been sanded previously to apply a coat nearer 2 inches in thickness. The sand is of value in several ways: First, if the coat is sufficiently thick it prevents the emergence of the moths; and, second, it covers the trash on the bog floor, producing clean conditions unfavorable for girdler infestation. In locations where girdler injury has already occurred it covers the injured vines, causing them to throw out new roots, and invigorating them to such an extent that recovery is rapid.

For those who undertake the sanding method of controlling girdlers it should be borne in mind that there is some risk, attendant upon this practice, of increasing the fungous troubles of the fruit, and one should be prepared to spray sanded bogs with a fungicide such as Bordeaux mixture.

Experimental work is not altogether conclusive as to the thickness of the coat of sand which will prevent emergence of the moths from cocoons. Franklin (11, p. 19) found that an even covering of sand 1 inch in thickness effectually prevented moth emergence in small cages, while the writer's data, obtained in a mosquito-bar cage placed on a cranberry bog, lead him to conclude that an even coat, 1 inch in thickness, will not be obtained by the grower in the actual practice of sanding and that considerable numbers of moths will emerge through the sand.

The sanding experiment performed at Whitesbog, N. J., was essentially as follows: Three plats were laid off where the vines showed severe injury and where, in fact, they had been killed over a considerable extent. Two of the plats were sanded fairly evenly on November 23, 1914, the depth varying from an inch to an inch and a half. The winter flowage was put on in December and removed May 8, 1915. The same day three cocoons were removed from beneath the sand in plat 2, and on May 10 two cocoons were dug out, all of which contained live larvæ. A tight mosquito-bar cage (Pl. II, B) was built over the three plats a few days later, and emergence of moths was first noted June 10, 1915.

TABLE VII.—*Emergence of moths of the cranberry girdler in sanding experiment at Whitesbog, N. J., 1915.*

Date.	Number of moths emerged.		
	Plat 1, area, 173 square feet, sanded.	Plat 2, area, 248 square feet, check.	Plat 3, area, 222 square feet, sanded.
June 10	4	12	0
June 11	7	41	0
June 12	10	34	1
June 15	41	64	12
June 16	18	3	3
June 18	21	8	9
June 25	4	1	5
July 2	0	0	1
July 8	1	0	0
Total	106	160	31

Owing to the distance of the cage from the field laboratory it was not practicable to remove and count the moths each day. The data show that the greatest number of moths emerged from the unsanded plat, which was also the largest plat, but that 1.55 moths emerged per square foot in the unsanded plat as compared with 1.61 moths in plat 1, sanded. Plat 3 was known to have a lighter infestation than the others when the experiment was started.

There were one or two places, particularly around a stump, on the sanded areas where the sand had washed a little thin during the period of winter flowage, but these spots were insignificant in size, and the data presented lead to the conclusion that a 1-inch coat of sand applied under natural bog conditions with a great deal more care than would be given by the average grower is not effectual in preventing the emergence of girdler moths from their cocoons.

RECOMMENDATIONS FOR CONTROL.

The most effective control measure that the writer has seen applied for this insect is the fall flooding immediately after picking the crop, when this operation can be completed in time to apply the water before the last of September. This treatment is effective, because it comes before the worms have spun their cocoons, and a reflow lasting not more than a week is undoubtedly of sufficient duration to kill all naked girdler larvæ.

If the berries can not be removed from the vines in time to permit fall flooding before the last of September, or if the water supply is insufficient, the next best method of control is to hold the winter flowage over the vines until July 20, thereby losing one crop of berries, but gaining a clean bog and the possibility of having a crop twice the normal in quantity the following year.

In the event that the foregoing remedies can not be employed, recourse may be had to sanding and better cultural methods. It is doubtful if a coat of sand less than 1½ inches in thickness can be relied upon to prevent emergence of the girdler moths and, while this is an expensive operation, there are many New Jersey bogs, particularly those having peat or mud bottoms, which would be benefited greatly by a thorough sanding. A 1-inch coat of sand will be found of value for invigorating injured vines and in so far as it covers the trash on the bog floor will render conditions less favorable for further infestation by the girdlers. If the fruit produced on sanded lands is less sound than it was prior to sanding, this condition may be corrected to a large extent by spraying with Bordeaux mixture in the proper season.

Pruning, along with sanding, should be practiced, and these measures, together with the removal of obnoxious weeds and grasses, constitute better cultural methods, all of which aid very materially in making cranberry vines healthier and freer from damaging insects.

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